NINTH EDITION

Questions in Machine Construction and Drawing

Stages 1, 2 and 3. With Illustrations

For the use of Students preparing for Engineering Examinations, etc.

By

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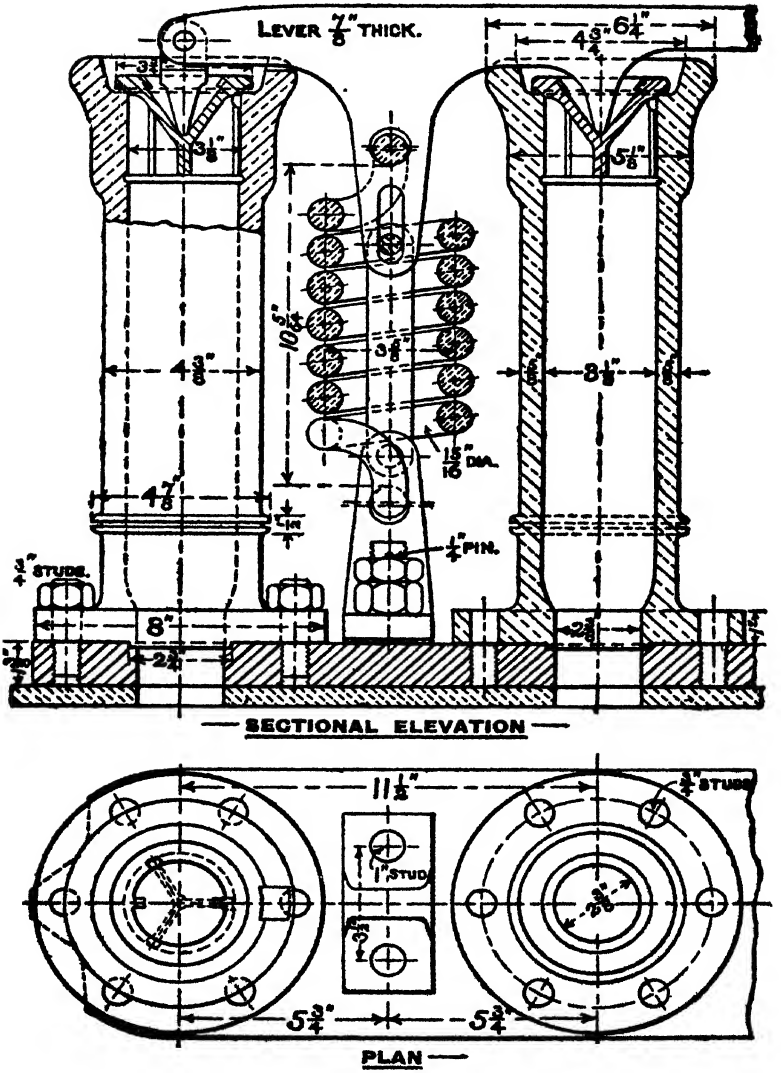
DETAILS OF SAFETY VALVES

MIDLAND RAILWAY

FOR EXPRESS PASSENGER ENGINE



This is a Specimen Drawing from
"BENTLEY'S SKETCHES OF ENGINE AND MACHINE DETAILS"

PART 1. STAGE 1

Riveted Joints

All Sketches to be done Freehand

1. Make neat sketches showing the different forms of finished Rivets employed for joining Boiler Plates, &c.
2. Show the construction of the following Riveted Joints, viz.:
   (1). Single Riveted Lap Joint.
   (2). Double Riveted Lap Joint.
   (3). Butt Joint, with Single Cover Plate.
3. In a Single Riveted Lap Joint the plates are $\frac{1}{2}$in. thick, what will be the Diameter and Pitch of the Rivets and width of the overlap?
   (*Ans.—Rivets $\frac{7}{8}$in. dia., pitch 2in., overlap 2$\frac{5}{8}$in.*)
4. Boiler Flue Plates are fastened together by means of Adamson's Rings or Bowling Hoops. Show by sketches how this is done, and explain the use of same.
5. *Sketch sections of Angle, Tee, and Channel Iron. Give two views showing how two Wrought Iron Plates are connected together at right angles to one another by means of angle iron and rivets. What diameter of Rivets would you use for $\frac{1}{2}$in. Plates? (*Ans., $\frac{7}{8}$in. dia.*)
6. It is required to connect Parallel Plates together such as are used in Locomotive Fire Boxes. Show three methods of doing this.
7. Why is it better to drill the holes in Boiler Plates in preference to punching them?
8. Give sketches showing the construction of a T-iron Joint, and give two examples of its use.
9. Mention two ways in which the ends of a Lancashire Boiler may be prevented from bulging.

Note.—Questions marked with an asterisk (*) are taken from the Board of Education Examination Papers, by kind permission of the Controller of His Majesty's Stationery Office.

Bolts, Nuts and Screws

10. Sketch a bolt with square head and hexagon nut. Supposing the bolt to be 1in. in diameter, mark on the usual dimensions of the nut and bolt head; also give size of washer.

11. Show how two Cast Iron Plates are fastened together by means of bolts.

12. Make sketches showing (1) Tee Head Bolt; (2) Eye Bolt; (3) Hook Bolt; (4) Screws; (5) Cup Head Bolt; (6) Set Screw; (7) Fang Bolt; (8) Stud; (9) Set Bolt; and give an example of their uses.

13.* Make a sketch of a Stud, describe how it is screwed into place, and state some circumstances under which it is used in preference to a bolt.

14. Show the three forms of Bolts usually employed for securing Engine Beds, etc., to stone foundations, *viz.*: (1) Cotter Bolt; (2) Rag Bolt; (3) Lewis Bolt; and show how they are fixed in position.

15. In machinery, Nuts are liable to work loose by vibration. Sketch two or three methods showing how to prevent this.

16.* Show by sketches the forms of triangular, square and buttress threads. What is the angle of the threads, and what is the Pitch?

17. Show one or two methods employed to prevent Bolts from turning when screwing up the Nuts.

18.* Show the form of a Whitworth Screw Thread by drawing to scale a part section of two or three threads taking a Pitch of 1½in. Figure the dimensions on the sketch.
How many threads to the inch are used on an inch Bolt?
(*Ans.*—8 threads.)

19. Make sketches showing two or three forms of spanners used for tightening up Bolts and Nuts.

Keys and Cotters

20. Explain the use of a Split Pin; also of a Taper Pin.

21. Show by sketches how to fasten a wheel or pulley on to a shaft by means of a (1) Flat Key, (2) Sunk Key, (3) Saddle Key.

22. What is meant by "Staking" on? Illustrate your answer by a sketch.

23.* Show by sketches how a wheel is fixed on to a shaft by means of a sunk key. Explain how the key may be withdrawn when it cannot be driven from the point end.

24. What is the object of making a key or cotter with a head on?

25.* Distinguish between a Key and a Cotter. Draw an example of each, stating the purpose for which each is employed.

26. What are the usual proportions of Keys used for fastening wheels and pulleys on to shafting?
(ANS.—*Let B=Breadth, and T mean thickness of Key, D=Diameter of Shaft:* *then* $B=\frac{D}{4}+\frac{1}{8}''$, *T in sunk Key*$=\frac{D}{8}+\frac{1}{8}''$, *T in Key on flat*$=\frac{D}{10}+\frac{1}{16}''$).

27. What is the taper usually given to Keys? What size of Sunk Key would you employ for fastening a wheel or pulley on to a shaft 3in. diameter?
(ANS.—*Taper varies from* 1 *in* 64, *to* 1 *in* 96; *key* $\frac{7}{8}''\times\frac{1}{2}''$).

28.* Show two methods by which a Cotter may be prevented from slacking back.

29. Sketch one or two forms of feather keys suitable for a "Sliding Motion" such as are used on the back shaft of a lathe.

30. What is meant by the "Draw" of a Cotter?

Pipes and Cylinders

31.* Describe with sketches two methods by which the joints are made in connecting lengths of cast iron pipes.

32. Make neat sketches showing the construction of a Hydraulic Pipe Joint; explain how the joint is made watertight. How are the bolts prevented from turning in the bolt holes when screwing up the nuts?

33.* Sketch partly in section a union nut and joint for connecting two lengths of small piping.

34. Show the construction of a Cylinder for a Hydraulic Press, and explain how the ram is made to work watertight by means of the cup leather packing.

35. Sketch one form of Cylinder suitable for a Vertical Steam Engine.

36.* With the aid of sketches describe how a steam-tight joint is made between the cylinder and cylinder cover of a steam engine. If the cylinder cover carries a stuffing box for the piston rod, show how the cover is fitted so that the centre line of the rod must exactly coincide with the centre line of the cylinder.

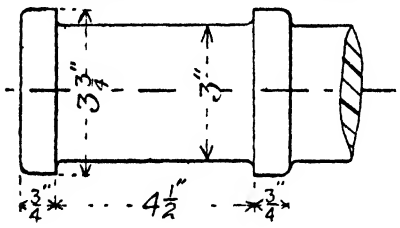
37. Give sketches showing (1) The construction of a "Leaded" Socket and Spigot Joint for large diameter water pipes, (2) of a Flexible Ball Joint for pipes.

38. Make sketches of the following pipe connections: (1) Hexagon Nipple, (2) Oval Flange, (3) Y-branch, (4) Elbow, (5) Flange Union, (6) Return Bend.

39. Show two methods of connecting the separate lengths of wrought iron or steel pipes.

Shaftings and Couplings

40. Show the usual form of Shaft "neck," or journal, and explain the use of same. Supposing the shaft to be 3in. dia., mark on your sketch the length of "neck" and diameter and thickness of the two fast collars.



(ANS.—*The object of a Shaft journal is to prevent the "end motion" of the Shaft—see Sketch.*)

41. What are loose collars used for? Give two examples of their use.

42.* Give sketches showing how the separate lengths of a line of Shafting may be connected together.

43. Make neat sketches showing the construction of a Flange Coupling used for joining Mill Shafting.

44. Show the construction of a Half-lap Coupling, also of a Butt or Muff Coupling.

45. In some Flange Couplings the Bolt-heads, Nuts and Washers fit in circular recesses to avoid projections; in this case, a box key is employed for tightening up the bolts. Make a sketch showing this form of Key.

46. What materials are usually employed for Shafting? State the reasons why they are used.

47. Give sketches and description of any form of disengaging Coupling you may be acquainted with.

Pedestals, Plummer Blocks, Hangers, etc.

48. Make sketches of a Simple Bearing for supporting Shafting, and show how the brass brush is held in its position.

49. Make neat sketches showing the construction of an ordinary Pedestal or Plummer Block, and explain how the Brasses are adjusted when they become worn.

50.* Sketch the Brasses for a Bearing, and show how they are prevented from turning in the Pedestal.

51. Show one form of Hanger suitable for supporting Mill Shafting, marking on the names of material employed.

52. Sketch and describe one form of Adjustable Hanger for supporting Shafting, and state the advantages of the same.

53. Show detailed sketches of a Footstep Bearing suitable for supporting a Vertical Shaft, and explain the process of fitting up same.

54. Make sketches showing a Wall Box, with Pedestal and Shaft in position.

55. Show by sketches (1) a Wall Bracket for carrying Shafting, making clear how it is attached to the wall of the workshop; (2) a Pillar Bracket for supporting a Horizontal Shaft.

56. What are "chipping" or facing strips? Where do they occur on a Pedestal?

57. Sketch the "angle" Pedestal used for Crank Shaft Bearings, and show clearly how to lubricate same.

Toothed Gearing

58. Make neat sketches of a Spur Wheel, marking on the proportions of the teeth.

59. What is the meaning of the terms Pitch, Breadth of Face, Thickness of Tooth, Pitch Line, Rim, Nave, and Arm, as applied to toothed gearing?

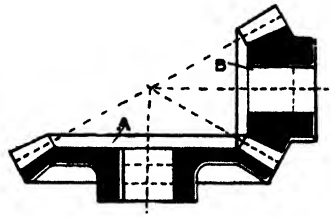
60. Find the diameter of the Pitch circle of a Spur Wheel having 60 teeth 2in. pitch. (ANS.—38·19in.)

61.* Describe how the parts of a large Spur Wheel are put together, and explain why the wheel is made in segments.

62. When Shafts are required to work at right angles to each other, they are connected by Bevel or Mitre Wheels. Give sketches showing how this is done.

The sketch shows a pair of bevel wheels in section. When both the wheels are the same size they are called *mitre-wheels.*

A. Wheel.
B. Pinion.



63. Sketch the Rim of a Spur Wheel with shrouded teeth. What is the object of shrouding?

64. Make a neat sketch of a Mortice Spur Wheel, and explain how the teeth are secured to the Rim.

65.* A Spur Wheel has teeth of 3in. Pitch. Sketch a Tooth and mark on it the thickness at the Pitch line and the height above and below the Pitch line.

66. A Shaft running at 50 revolutions per minute has on a Bevel Wheel with 48 teeth gearing into another Wheel with 80 teeth. Find the speed of the second shaft.
(ANS.—30 *Revolutions.*)

67. Show the construction of a pair of Bevel Wheels in section.

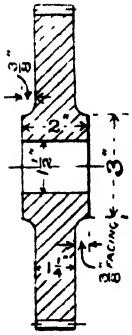
68. Make neat sketches showing a Rack and Pinion. Give one or two examples of the use of same.

69.* Show by a sketch what is meant by Clearance of Wheel Teeth?

69A. A Gear Wheel has 45 Teeth, 5 Pitch; find

(1) Pitch Line Diameter.
(2) Diameter of Blank.
(3) Weight of Cast Iron Blank.

(See Sketch)



(1) *Pitch Line Diameter.*

$$= \frac{\text{Number of Teeth}}{\text{Diametral Pitch}} = \frac{45}{5} = 9'' \text{ Ans.}$$

(2) *Diameter of Blank.*

$$= \frac{\text{*Number of Teeth} + 2}{\text{Diametral Pitch}} = \frac{45+2}{5} = 9.4'' \text{ Ans.}$$

(3) *Weight of Blank.*

(Neglecting facing and hole)

$= (9.4^2 \times .7854 \times 1\tfrac{1}{4}'') \cdot 26.$
$= 86.7 \times .26$

Weight of Facings.

(Neglecting hole.)

$= (3^2 \times .7854 \times 2 \times \tfrac{3}{8}'') \cdot 26.$
$= 5.3 \times .26$

Weight allowed for 1½" Hole.

$= (1\tfrac{1}{2}^2 \times .7854 \times 2'') \cdot 26.$
$= 3.53 \times .26$

$\therefore$ Weight of Blank $= (86.7 + 5.3 - 3.53) \cdot 26.$
$= 23\ lb.$ Ans.

Note.—.26 lb. is the weight of 1 cubic inch of cast iron.

Belt Pulleys

70. Make neat sketches of a Belt Pulley with straight arms; also of a Pulley with curved arms, and state what is the advantage of the latter kind.

71. It is required to make a Cast Iron Pulley 3ft. 6in. dia., what size would you make the pattern to allow for contraction. (Ans.—3 *ft.* $6\frac{7}{16}$ *in.*)

72. *Explain why the diameter of a Belt Pulley is often made greater at the centre than at the edges. Give the reason why the arms of Cast Iron Pulleys are often curved.

73. Show by sketches how a fast and loose Pulley are fixed on to a Shaft.

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* See *Machine Shop Companion* for rules on gearing.

74. What is the object of using "Cone" Keys for fastening Pulleys on to Shafting?

75. Make neat sketches showing the sections through the Rim of a Rope Pulley suitable for cotton or hemp Ropes, and also for wire Ropes.

76. Show by sketches the construction of a Five-Speed Cone, and explain the use of the same; also, show the construction of a Hardwood Split Pulley.

77. Pulley arms are chiefly made of two forms of section; make a sketch showing each form.

78. Make neat sketches showing the construction of a chain Pulley Block and Hook.

79. Show two or three methods of joining leather Belting by means of laces or rivets.

Cranks, Levers and Eccentrics

80. Show by sketches two forms of Cast Iron Cranks, one with a single "web" and one with a double "web."

81. Make neat sketches showing the construction of a Locomotive Crank Shaft.

82. Make sketches of a Wrought Iron Crank, also of a Disc Crank.

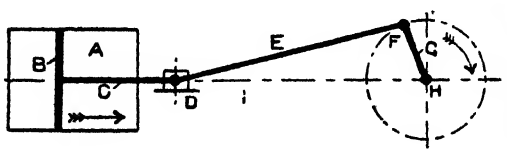
83. What is meant by the "throw" of a Crank?

84. Show how a Crank is fastened to a Crank Shaft, and also explain clearly how a Crank Pin is fixed to a Crank.

85. With the aid of sketches show a Built-up Steel Crank Shaft as employed in marine engines.

86. Give an example of the use of a Bell Crank Lever.

87. Make a diagrammatic sketch showing the various parts of a Steam Engine.



A ... Cylinder.
B ... Piston.
C ... Piston Rod.
D ... Crosshead.
E ... Connecting Rod.
F ... Crank Pin.
G ... Crank.
H ... Crank Shaft.

88.*By means of a sketch and description, show how the two parts of an Eccentric Sheave are joined together when the Sheave cannot be passed over the end of the Shaft.

89. Make sketches showing the construction of an Eccentric, and state what it is used for. What is meant by "eccentric radius" and the "throw" of an eccentric? Show clearly how it is lubricated.

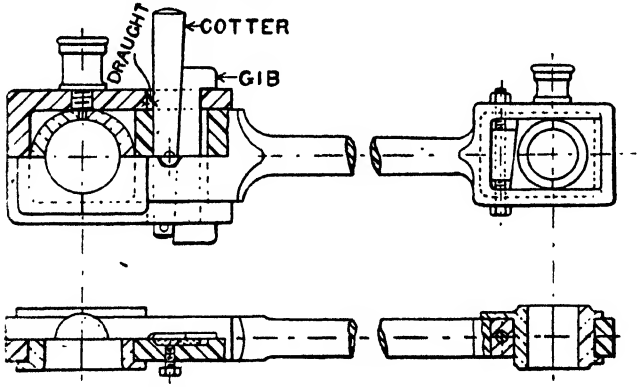
90. Show two methods of fixing the Eccentric Rod to the strap.

Links or Connecting Rods

91. Make neat sketches showing one form of Connecting Rod End suitable for a Horizontal Steam Engine, and explain how the Brasses are adjusted when they become worn. Make separate detail sketches of each part, and insert dimensions.

92. Show how adjustment is made for wear of the Brasses in a box ended Connecting Rod. How would you lubricate the Crank Pin? (*See right-hand half of Sketch below.*)

93.*Sketch a Connecting Rod End with Strap, Gib, and Cotter. Explain the use of the Gib.



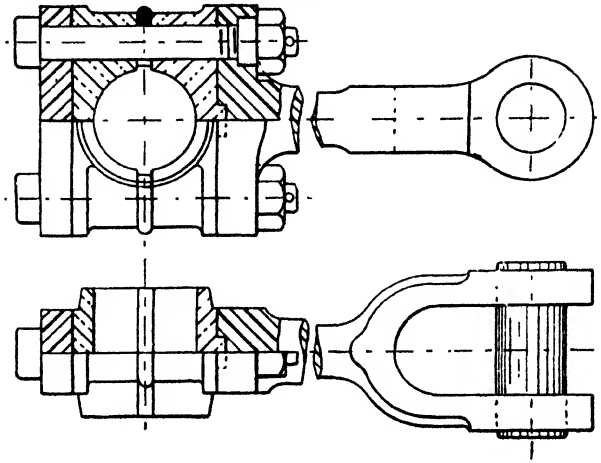
(ANS.—*The Gib prevents the Strap from opening out at the ends.*)

94. Sketch a Locomotive Connecting Rod End and show clearly the method of lubricating same.

95. What materials are employed in the construction of a Connecting Rod? State the reason why they are used.

95A.—How would you mark out and machine the various parts of the connecting rod illustrated above?

96. Make sketches of a Connecting Rod with "forked" end suitable for a Marine Engine.



97. What is meant by the term "draught" as applied to Connecting Rods? (*See Sketch on the previous page.*)

98.* Give sketches of a Connecting Rod for a Steam Engine, and explain how the exact length of the Rod may be maintained whilst adjustment is made for wear of the brasses.

99. Show by sketches the construction of a Coupling Rod End suitable for a Locomotive Engine, and explain clearly the use of same.

99A. Make dimensioned sketches of the separate parts of the Crosshead illustrated on page 22.

Pistons

100. Give sketches showing the construction of one form of Piston suitable for a Locomotive Engine.

101.* Explain how Piston Rings are made so that the Piston may work steam-tight in the Cylinder. How are these rings got into place?

102.* What is meant by the "Draw" of a Cotter? Make a sketch showing how a Crosshead is secured to a Piston Rod by a Cotter.

103. What is meant by "Piston Speed"? Estimate it in the following example. Revolutions per minute 150, length of Crank 18 inches. (ANS.—900 ft. per min.)

104. A Piston runs 400 ft. per minute, and the Crank makes 50 revolutions in the same time. What is the length of the Crank? (ANS.—2 feet.)

105. Sketch and describe one or two methods of attaching the Piston Rod to the Piston of an Engine.

106.* With the aid of sketches show how a Piston Rod is made to work steam-tight through the end of a cylinder.

107. What materials are employed in the construction of a Steam Engine Piston?

108. What kind of Piston Packing is usually employed to prevent leakage of steam?

109. Sketch a Piston suitable for a "Double Acting" Pump.

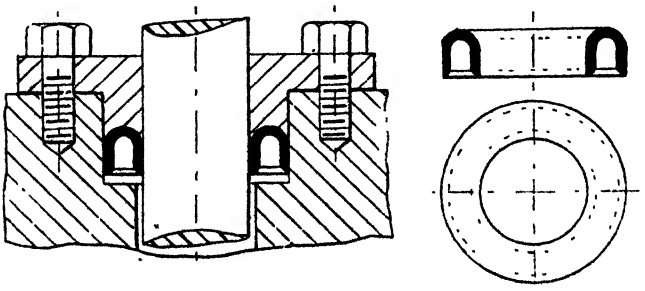
Stuffing Boxes

110.* Make neat sketches showing a Cylinder Cover with Stuffing Box and Gland complete, and explain the object of the same, showing method of lubricating Piston Rod.

111. Show one or two forms of small Stuffing Boxes with Screwed Glands, and state what kind of packing is used.

112. Explain clearly how a Stuffing Box "Gland" may be tightened up when the packing becomes worn.

113. In Hydraulic Presses, cup leather packing is employed to prevent leakage of water. Give sketches showing how this is done, also make separate detail of the cup leather. (See sketch.)

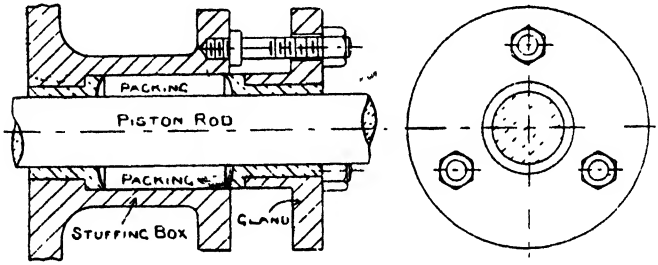


114. Show how Lubrication is provided for in the Stuffing Box for (1) Vertical Steam Engine; (2) Horizontal Engine.

115. What metals are employed in the construction of Stuffing Boxes?

116. Give sketches showing how you would pack the "Plunger" of a Force Pump in order to prevent leakage of water.

117. Why are Stuffing Box Glands lined or bushed with brass? Give sketches showing the ordinary type of Stuffing Box and Gland.



Valves and Cocks

118. Make sketches showing the construction of an ordinary Wing Valve and Seat.

119. Sketch a Conical or Puppet Valve, showing how it is guided in lifting.

120. Sketch a Throttle Valve. For what purpose is it commonly used? How is it actuated?

121. Show by sketches the construction, and explain the use of, the following Valves:

(1) Leather Flap or Clack Valve. (2) Ball Valve.
(3) Butterfly Valve. (4) Lever Safety Valve.
(5) India-rubber Disc Valve.

122. Give sketches showing the construction of the ordinary D-slide Valve employed on Steam Engines, and explain the action of same.

123. Show in section a Stop Valve suitable for either Steam or Water, marking on the materials used.

124.* Give sketches showing one method of attaching the Valve Rod to an ordinary Slide Valve.

125. Show the construction of a "Blow-off" Cock used on Steam Boilers.

126.* What is the use of a Watergauge Cock? State exactly where it is placed on the Boiler.

127. Give sections of a two-way Plug Cock, also of a three-way Cock.

Miscellaneous Questions

MACHINE TOOLS, ETC.

128.* Show by sketches how you would secure a piece of work to the table of a Slotting Machine.

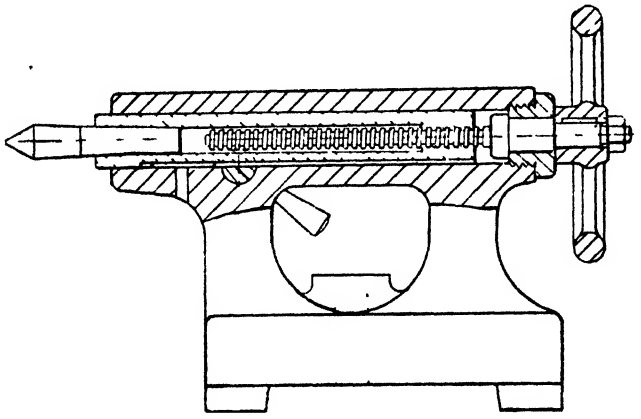
129.* What is the object of using Chipping or Facing Strips in fitting up Machine Parts? Give one or two examples.

130.* Give sketches showing you would grip and drive a round iron bar for the purpose of turning it between the centres of a Lathe.

131.* Give sketches showing how the Cutting Tool of a Lathe or other Machine is secured in place.

132.* Explain the use of the quadrant for change wheels for a Screw Cutting Lathe by making a sketch showing it in place on a Lathe with wheels in gear.

133. Make a sketch showing clearly the construction of a Loose Headstock for a Lathe.



LOOSE HEADSTOCK FOR LATHE

134. Make neat sketches of a "stay" used on Lathes for supporting Shafting, etc., whilst being turned.

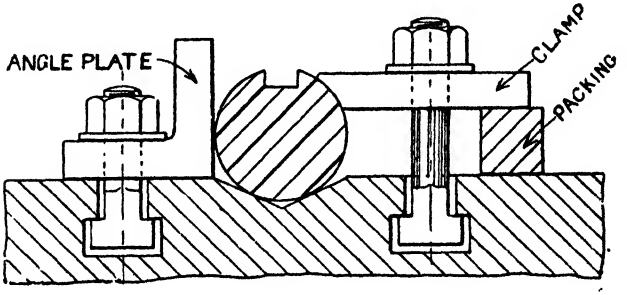
135.* Make a sketch showing how the adjustment is made in the sliding parts of Machine Tools, as for example in the slide rest of a Lathe.

136. Show how to fix an ordinary drill in the "nose" of drill spindle.

137. Give sketches of a Boring Bar with flat steel cutter.

138. Show how "end motion" of a spindle may be prevented by the use of a "groove and pin."

139. Show one method of securing a Shaft on a Planing Machine table whilst a long Key-way is being planed in. (See Sketch.)



139A. Make neat sketches of Weston's Differential Pulley Blocks, and explain the action of the same.

140. Give working sketches showing the fast or driving headstock for a Double-geared Lathe; name the materials the different parts are composed of.

141. Show the common forms of Lubricators employed for lubricating Shaftings, Bearings, Connecting Rods, etc.

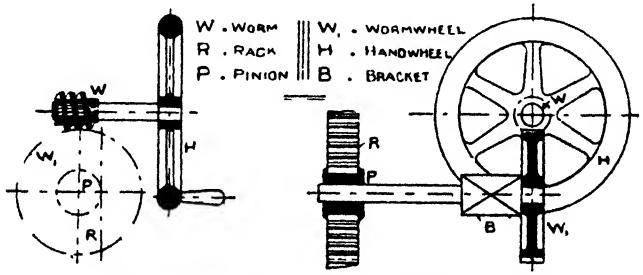
142. Show a four-jaw Chuck suitable for a 7in. Centre Lathe, and explain its object.

143. Show working sketches of a Bottle Screw Jack suitable for lifting a weight of two tons; mark on Diameter and Pitch of Screw.

144. Make neat sketches, showing one or two forms of Bench Vice employed in fitting shops.

145. Show by sketches the different kinds of Drills (ordinary and twist) employed in machine shops; also chipping chisels, scrapers, gauges, and inside and outside chasing tools.

146. Give sketches showing the mechanism for highering and lowering the table of a Drilling Machine.



147. Give working sketches of a "Knuckle Joint" supposing the two rods to be §in. diameter; mark on the dimensions of the joint.

148. Make sketches showing the countershaft and overhead motion suitable for driving a Lathe or other machine.

149. Show the application of a Ratchet Wheel in connection with a "Sight" Feed Lubricator for a Steam Engine Cylinder.

150. Show the different forms of cutting tools employed on a Screw Cutting Lathe; also one or two forms of tool holders.

151. Show by the aid of sketches how the Guide Screw of a Lathe is attached to the Lathe Bed; also explain how connection is made between the screw and the "saddle."

152. Make detail sketches and give description of a Ratchet Brace, showing how it is applied to the work requiring drilling.

153. Give sketches showing the construction of:

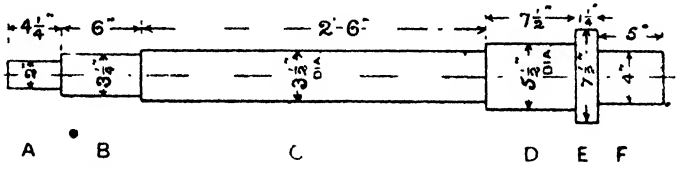
(1) Centring Square.
(2) Scribing Block.
(3) Stocks and Dies.
(4) Centring Punch.
(5) Surface Plate.
(6) Taps and Tap Wrench.

and explain the use of same.

154.* Describe in sequence how to secure and adjust a piece of a machine in a four-jawed Dog Chuck so that it may run as truly as possible in a Lathe.

154A.* In a back-geared lathe describe with sketches (1) how the back shaft is arranged so that it may be put in and out of gear; and (2) the method of securing the cone pulleys to the lathe spindle when the back gear is out of use.

154B.* Calculate the weight of the solid steel spindle shown in sketch.



Find the Volume of each part separately.

Volume of A	$= 2^2 \times \cdot7854 \times 4\frac{1}{4} =$	13·35	cubic inches.
,, B	$= 3\frac{1}{8}^2 \times \cdot7854 \times 6 =$	49·77	,,
,, C	$= 3\frac{1}{2}^2 \times \cdot7854 \times 30 =$	288·63	,,
,, D	$= 5\frac{1}{2}^2 \times \cdot7854 \times 7\frac{1}{2} =$	178·18	,,
,, E	$= 7\frac{1}{2}^2 \times \cdot7854 \times 1\frac{1}{4} =$	55·22	,,
,, F	$= 4^2 \times \cdot7854 \times 5 =$	62·83	,,
Total Volume of Spindle	...	647·98	cubic inches.

The weight of One Cubic Inch of Steel varies from 0·28 to 0·3 lb.

Weight of Spindle $= 648 \times 0{\cdot}28 =$ **181·44** lb.

Materials Used in Machine Construction, etc.

155. Name the materials used in Machine Construction.

ANS.:

1. Cast iron.
2. Wrought iron.
3. Cast steel.
4. Forged steel.
5. Copper.
6. Zinc.
7. Tin.
8. Gun metal.
9. Brass.
10. Phosphor bronze.
11. Muntz metal.
12. Manganese bronze.
13. White metal or Babbitts).
14. Wood.

156. What kind of Wood is usually employed for Patterns? Give the reasons for its use.

157. What is Cast Iron? Why is it so extensively used in Machine Construction.

158. State what you know about Wrought Iron and Steel, and give examples of the use of the same.

159. What is Brass composed of? Give examples of its use in Machine Construction, and state the reasons why it is used for those parts you name.

160. What do you understand by "forging" and "welding"? Explain the process and state what metals may be forged or welded.

161. In making patterns it is usual to allow "strip" or taper; why is this? Also state the usual allowance made for contraction.

162. What are Core Boxes used for? Make a sketch of one, and explain the use of Core prints.

163. Explain the process of Building up a Pattern for a Belt Pulley.

163A. Why are castings sometimes chilled? Describe the process of chilling.

PART 2. STAGES 2 & 3.

Riveted Joints

All Sketches to be done Freehand.

164. Show by sketches the principal forms of Riveted Joints employed for boiler work, etc., including Single, Double, Zigzag, and Chain Riveting. In a Double Riveted Lap Joint the plates are $\frac{3}{8}$-in. thick, mark on your sketch the diameter of the rivets, pitch of rivets, and width of overlap.

165. Illustrate a Rivet in "single shear," also a Rivet in "double shear."

166.* Show in how many ways a Riveted Joint may give way.

167.* Make sketches showing the method of Joining the plates of a Cylindrical Boiler at a point where a longitudinal joint meets a ring joint.

168. Give sketches showing the construction of a Combined Lap and Butt Joint.

169.* In a Single Riveted Lap Joint the plates are $\frac{1}{2}$-in. thick, Rivets $\frac{7}{8}$-in. diameter, Pitch $2\frac{1}{4}$-in. Supposing equal areas are required for equal strengths of Rivet and plate, find whether the joint will fracture by tearing or by shearing. (ANS.—*By shearing.*)

170.* Show how the cylindrical shell of a Lancashire or Cornish Boiler is connected to the flat end plates.

171. With the aid of sketches show how a Lap Joint is made where three plates overlap.

172. Give sketches and description of a "Gusset" stay employed in the construction of Steam Boilers; what is the object of the same.

173. Sketch the usual form of Plate Girder, and show how a Built-up Box Girder is constructed, also show a "Warren Girder."

174. Make neat sketches of a "Lozenge" Joint employed for connecting two plates of a Girder for roof or bridge work.

NOTE.—Questions marked with an asterisk (*) are Examination Questions.

175. What do you understand by "caulking and fullering" as applied to Riveted Joints for Boiler Plates?

176. Sketch three methods adopted to prevent collapse of Boiler Furnace Tubes.

177. Make sketches of "Galloway's" water tubes for Steam Boilers showing clearly how they are fixed to the furnace tubes.

Bolts, Screws, etc.

178.* Make sketches showing the various forms of Bolts, Studs, Screws, and Nuts, which are commonly employed in securing together the parts of a Machine made of metal. Quote an example of the use of each.

179. What is the Pitch of a Screw? Give sketches showing the Whitworth and other screw threads.

180. Distinguish between a right-handed and a left-handed screw. Give sketches and examples of the use of each kind.

181. Give working sketches showing the proportions of a Bolt Head and Hexagon Nut, suitable for a $\frac{3}{4}$-in. Bolt.

182.* What are the various ways in which a screwed Bolt and Nut may yield to the forces to which they are subjected? Give the dimensions of the Nut and screw thread of an inch Bolt.

183. Show one or two forms of Stay Bolts used for staying a wrought iron water tank; also give a longitudinal Stay Bolt suitable for staying a Lancashire boiler.

184. What is meant by "backlash" in Screws? Give sketches showing one or two methods employed for preventing backlash.

185. How would you determine the number and diameter of Bolts required for a steam-tight pipe joint, or cylinder cover?

186. How many Bolts, $1\frac{1}{2}$-in. diameter, are required for the cover of a cylinder, 56-in. diameter, the initial pressure of steam being 90 lb. per square inch, *the working stress on the Bolts not to exceed 2000 lb. per square inch of section of Bolts?* (ANS.—62·72, *or say* 63 *Bolts.*)

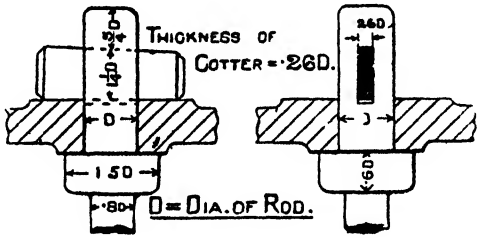
187. What is the disadvantage of using Bolts of less than $\frac{3}{4}$-in. diameter for steam-tight joints?

188. Of what materials are Bolts and Screws usually made? State the reasons for their use.

189. Give examples where Bolts are subjected (1) to tensile stress, (2) to shearing.

Keys and Cotters

190. Give several examples of the use of Keys and Cotters in machine construction. Of what material are they usually made?



191. Show the use of a Cotter in connection with a Gib for tightening the brasses in a connecting rod; also, in connection with a foundation bolt for fastening down an Engine Bed.

192. Give sketches showing the usual proportions for a "Cottered Joint" suitable for securing tie rods, etc.

193. What is the taper usually given to Keys and Cotters?

(ANS.—*Taper varies from* 1 *in* 64 *to* 1 *in* 96.)

194.* Sketch and explain the modes of fixing a Wheel or Pulley by a Sunk Key, by Cone Keys, and by Staking on.

195. Show one or two methods employed for fixing Cotters in order to make them secure.

196. Give sketches showing how you would fix a Piston Rod to a Crosshead by means of a Cotter.

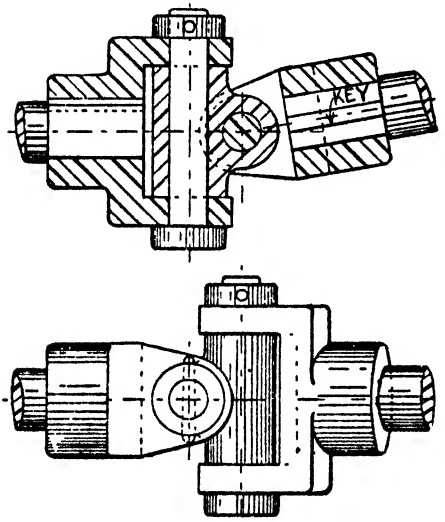
197.* Show by a sketch how the brasses of a Crank Shaft bearing are tightened horizontally by Cotters.

Shafting, Couplings and Clutches

198. Give working sketches showing one or two forms of Fast Couplings for joining together the different lengths of a line of shafting.

199. Show the construction of a 3-Claw Disengaging Coupling or Clutch, and explain how it is put in and out of gear.

200. Make neat sketches showing " Hooke's Joint " or Universal Coupling and explain its object.



(ANS. — *The sketch shows the construction of Hooke's Joint.*

This form of coupling is used for connecting two shafts whose axes intersect.

It has the advantage that the angle between the shafts may be varied while they are in motion.)

HOOKE'S JOINT OR UNIVERSAL COUPLING

201. Show the ordinary form of Cast Iron conical Friction Clutch.

202. Give sketches and description of any form of " Friction Clutch " you may be acquainted with.

203. Show how you would support a length of shafting to the roof of a workshop.

204. By the aid of sketches show the construction of a Propeller Shaft Coupling.

205. Explain the process employed in the construction of a Flange Coupling.

206. What horse-power will a 3-in. shaft transmit, running at 100 revolutions per minute? (ANS.—33·75 *H.P.*)

RULE.—*Multiply the cube of the diameter of shaft in inches, by the revolutions per minute, and divide by constant* 80.

207. If a shaft, 2-in. diameter, transmits 4 H.P., what will a 3-in. shaft transmit? (ANS.—13·5 *H.P.*)

Pedestals and Bearings

208. Show by sketches an ordinary Pedestal, and mark on the proportions suitable for a $2\frac{1}{2}$-in. shaft.

209. Give sketches showing a Pedestal where the brasses can be adjusted horizontally as well as vertically.

210. Show the construction of (1) Self-lubricating Pedestal, (2) Bearing for working under water, (3) Thrust Bearing for Propeller Shaft.

211.* Show by sketches the construction of an Axle Box for a railway carriage. Point out any special feature of this form of Bearing.

212. Give dimensioned sketches of a Wall Box and Pedestal suitable for supporting a 3-in. Shaft.

213. Show by the aid of sketches how you would support the "overhead motion" for driving a Lathe, etc.

214.* Show by sketches a corner Wall Bracket to carry the Pedestals of two Horizontal Shafts. The shafts are to be at right angles to one another, and connected by bevel wheels. Show the Shafts and Wheels in position.

215. Why are long Bearings used for high-speed Shafts? Make sketches showing same.

216. Sketch and describe one form of Footstep Bearing suitable for supporting a vertical Shaft, name the materials used, also explain how such a Bearing is lubricated.

Toothed Gearing

217. Make neat sketches showing the ordinary forms of Spur and Bevel Gearing used in machine construction; show also the forms of teeth usually employed.

218. Why is Cast Iron so extensively used for Gearing?

219.* It is required to connect two shafts at right angles by means of Bevel Gearing, and to be so that one shaft shall revolve three times while the other revolves two. Sketch the arrangement and give the number of teeth in each wheel.

(ANS.—*The number of teeth may be* 20 *and* 30 *respectively.*)

220. What power may be transmitted through a Spur Wheel 4-ft. diameter, 6-in. broad, and 2-in. pitch, running at 75 revolutions per minute? (ANS.—25·13 *H.P.*)

RULE.—*Multiply the breadth of the teeth in inches* $\times$ *the square of the pitch in inches* $\times$ *the velocity at the pitch line in feet per second, then divide by constant* 15.

221.* Give two views of a tooth of a Mortice Spur Wheel showing how it is fitted into the rim of the wheel and held in position. Under what circumstances would you use Mortice Wheels?

222. Show sketches of a Worm and Worm Wheel, and give examples of the use of same.

223. What are the sections usually employed for the arms of Spur Wheels? Also state what is meant by a Shrouded Wheel.

224. Give sketches showing a Chain Wheel, also show the construction of various kinds of chain for same.

225.* The wheels of a back gear of a lathe have 50 and 16 teeth respectively, the pitch being the same in each. The smaller wheel on the lathe mandril has 18 teeth; what number of teeth should the larger wheel have? If the mandril makes 100 revolutions per minute with the back wheels out of gear, how many revolutions per minute will it make with the back gear in, the position and speed of the belt being unaltered?

(ANS.—52 *teeth and* 11 1-13 *revs.*)

226. What are Helical Teeth?

227. Show the method of constructing a built-up Fly Wheel, and explain the advantages of same.

Belt Gearing

228. Give working sketches showing one or two forms of Belt Pulleys with straight arms, and also with curved arms.

229. Make sketches showing a stepped "Speed Cone," and explain the advantages of same.

230.* A shaft running at 100 revolutions per minute drives another by a leather belt; Pulley on first shaft 18-in. diameter; Pulley on second shaft 30-in. diameter; find the speed of the second shaft. Suppose the same belt is to drive the second shaft at 40 revolutions per minute, find the diameter of the two pulleys.

(ANS.—60 *revolutions, and* 45-*in. and* 18-*in.*)

231. What are Guide Pulleys? Give sketches of same and illustrations of their use.

232. A Belt works upon two Pulleys, one 3-ft. diameter, and the other 2-ft. 8-in. diameter, the distance between the centres of the shafts is 24-ft. 6-in. Find the length of the Belt. (ANS.—57·9 *ft.*)

233. Make sketches of a fast and loose Pulley.

234. Make sketches showing the construction of wrought-iron "Split Pulley."

235. Give sketches showing the different methods adopted for making the joints of Belting, viz.: with Laces, Rivets, or Bolts.

236. Sketch the section through the rim of one or two kinds of Pulleys, suitable for cotton or wire rope driving.

237. What horse-power can be transmitted by a single leather belt 12-in. wide, working on a pulley 3-ft. 6-in. diameter, and making 120 revolutions per minute, working tension 140 lb. per inch of width?

$$\text{H.P.} = \frac{42'' \times 120 \times \pi \times 12'' \times 140}{12'' \times 33{,}000 \times 2} = 33{\cdot}58 \text{ H.P.}$$

Linkwork

238. Make sketches of a Crank-shaft suitable for a Gas or Oil Engine.

239.* Give sketches showing the construction of an Eccentric Sheave and Strap, the Sheave being made in two parts.

240. Show the construction of a Crank-shaft Bearing which is provided with means of adjustment for horizontal and vertical wear.

241. Sketch the Crosshead and Slides for a Steam Engine, describe the same, using letters of reference.

242.* Give a skeleton drawing of a Link-Motion, showing the relative positions of the Eccentrics and Rods; mark by an arrow the direction of rotation of the Shaft, and indicate the forward and backward eccentric.

243. Make sketches showing the construction of the following Connecting Rod ends, viz.: (1) Strap ended; (2) Box ended; (3) Fork ended; (4) Locomotive; and (5) Marine.

244. Describe with sketches the construction of a Piston and Piston Rod, Crosshead and Connecting Rod suitable for Horizontal Engine, showing how the several parts are fitted together, and of what materials each part is composed.

245. What are Coupling Rods used for? Make neat sketches of same.

246. Show the application, and explain the advantages of renewable "slipper" pieces in the Guide Blocks of an Engine.

247.* Give two views with figured dimensions of a Knuckle or Fork Joint, suitable for connecting two rods of $1\frac{1}{2}$-in. diameter. Describe the process of machine-shaping the joint.

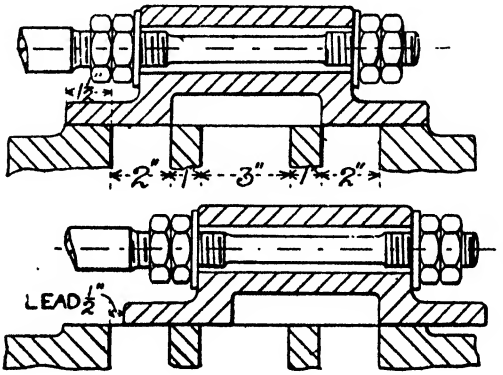
Valves and Cocks

248. Give sketches showing one or two forms of Slide Valves suitable for Steam Engines, also an Expansion Valve, and explain the use of same.

249. Define "outside lap," "inside lap," "lead," and "travel" of a Slide Valve. Make sketches illustrating your answer.

250.*Sketch a Slide Valve in mid-position to the following dimensions: Exhaust port, 3-in. wide; bars, 1-in. wide; steam ports, 2-in. wide; outside lap, $1\frac{1}{2}$-in. Sketch also the same Valve at the beginning of the piston stroke with $\frac{1}{2}$-in. lead. The Valve need not be drawn to scale, but may be sketched and dimensions marked on it.

(ANS.—*See sketch.*)



251. Show the construction of a Lever Safety Valve suitable for a Steam Boiler; describe the same, using letters of reference. The steam pressure in a boiler is 50 lb. per square inch: what weight will be required on the lever which is 24-in. long, the Valve being 3-in. diameter, and the distance from the fulcrum to the centre of Valve 3-in.? (ANS.—44·1 lb.)

252. Make a sectional elevation through a screw-down Stop Valve.

253. Show one or two forms of Plug Cocks, and state what they are used for?

254. What is a double-ported Valve? Describe the same, using letters of reference.

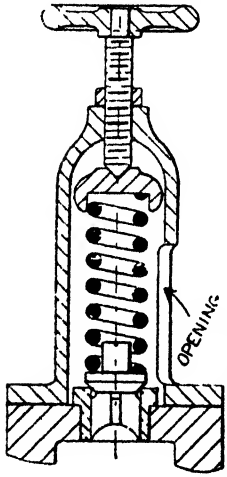
255. By means of sketches, show the construction of the following Valves: (1) India-rubber disc valve, (2) Double beat valve, (3) Ball valve, (4) Piston valve, (5) Throttle valve, (6) Corliss valve, (7) Sluice valve; stating the purpose for which each is employed.

256. Show the construction of the "Trick" slide valve for steam engines, and explain the object of same.

257. Make detailed sketches of a Spring safety valve for marine boilers, describing how it is adjusted.

258. Show the construction of (1) a Dead-weight safety valve, (2) a Regulator valve for a locomotive engine.

259. Make a sketch showing the section through a Cylinder Relief or Escape Valve; and explain the use of same.



CYLINDER ESCAPE VALVE.

(ANS.—*The sketch shows the construction of a cylinder escape valve. The valve is of the ordinary conical form, and is kept in position by a spring loaded a little above the pressure in the boiler.*

This kind of valve is often fitted on the cylinder covers of steam engines.

Its object is to avoid the danger of the piston bursting the cylinder cover as it approaches the end of its stroke, owing to the presence of water which may have accumulated in the cylinder either by "priming" or condensation. The pressure opens the valve and allows the water to escape.

Lubricators, etc.

260. Give sketches and description of the following methods of lubricating, with examples of their use: (1) Syphon Lubricator; (2) Displacement Lubricator; (3) Pad Lubricator; (4) Bath Lubricator; (5) Stauffer's Lubricator.

261.* Describe and illustrate by sketches an efficient method of lubricating: (1) a Pedestal for a line of Shafting; (2) a loose Pulley for an overhead Countershaft; and (3) the Piston and Slide Valve of a Steam Engine.

262. Sketch and describe one form of "Sight Feed Lubricator."

263. Give sketches and description of a Cylinder Oil Cup, or Tallow Cup.

264. Make a full-sized drawing of the ordinary "Needle" Lubricator, and explain its action.

265. Make neat sketches showing the ordinary form of "oil cup" with lid.

Miscellaneous Questions

ENGINES, ETC.

266. Sketch the horizontal section through the cylinder and valve chest of a Steam Engine, marking on which are the steam and exhaust ports.

267. Describe with a sketch the construction of a Piston with metallic packing suitable for a Steam Engine, and show how the several parts are fitted together.

268. Give working sketches and description of Porter's Governor for Steam Engines.

269.* Sketch a combined Slipper Guide and Crosshead for a Steam Engine, showing how the Piston Rod and Connecting Rod are attached. Also show how the Slide is lubricated.

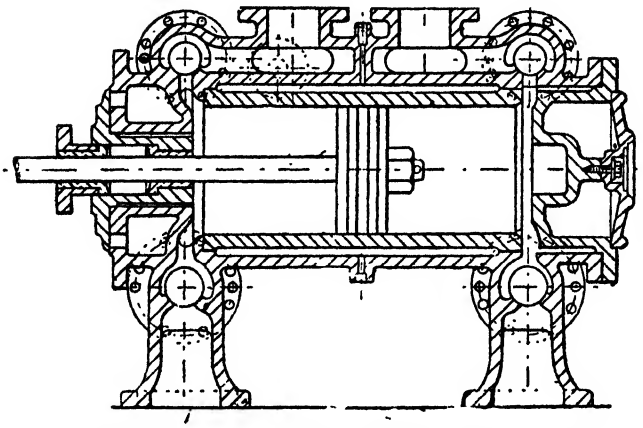
270.* Show by sketches the construction of a Hydraulic Piston suitable for high pressure.

271.* Explain with sketches one form of metallic gland packing for the Piston Rod of a Steam Engine. State the advantages due to the use of metallic packing as compared with other material.

272. Make neat sketches showing the construction of the following Valve Gears:

(1) Meyer's Valve Gear.
(2) Corliss Valve Gear.
(3) Proell's Valve Gear.
(4) Joy's Valve Gear.
(5) Trip Gear.

273. Sketch the vertical section through the Cylinder of a Corliss Engine. (*See sketch.*)



SECTION OF CORLISS ENGINE CYLINDER.

BOILERS, ETC.

274. Make outline sketches showing the construction of the following forms of Steam Boilers:

(1) Lancashire Boiler.
(2) Cornish Boiler.
(3) Vertical Boiler.
(4) Marine Boiler.
(5) Locomotive Boiler.

275. What are the usual mountings fixed on a Lancashire Boiler? Give sketches of same, and explain their use.

276. Make sketches showing:

(1) Longitudinal Stay Rod or Bolt.
(2) Diagonal Stay.
(3) Boiler Tube.
(4) Fire Box Roof Stays.
(5) Fox's Corrugated Furnace.

277. What materials are used in the construction of Steam Boilers, and why?

MACHINE TOOLS, ETC.

278. Give working sketches showing the fast or driving head-stock for a double geared Lathe, and explain how the different parts are fitted together.

279. *Sketch and describe a simple form of slide rest for a Lathe.

280. The overhead Countershaft, by means of which a Lathe is driven by a belt, is carried by brackets fixed to a wall, the Lathe standing against the wall. Sketch and describe a Strap-Fork arrangement by which the Lathe may be conveniently started and stopped.

281. Show two or three forms of slide rest tools, ordinary, and twist Drills; also sketch one or two "Milling Cutters," Chipping Chisels, Cross Cut Chisel, Chasing Tools, etc.

282. Describe the process of fitting up and erecting some machine tool with which you are acquainted.

283. Sketch the screw-cutting gear of a Lathe, and explain how you would proceed to cut a Screw.

284. Show by sketches how you would fix a piece of work to the table of a Milling Machine during the operation of milling.

285. Sketch one form of quick return motion as used on planing or shaping machines.

286. Show by what means the cutting tools are held in position on a lathe, planing, or slotting machine.

287. Sketch and describe one form of Machine Vice and explain its object.

288. Describe by the aid of sketches how you would proceed to turn and bore a Belt Pulley in a Lathe.

NOTE.

Students are recommended to take sketches and measurements direct from actual machines, engines, etc., and afterwards to prepare general and working drawings of same.

The following may be taken as suitable examples.

289. Steam, Gas, or Oil Engine.

290. Screw Cutting Lathe, 6-in. to 9-in. centres.

291. Turret Lathe.

292. Double Geared Drilling Machine.

293. Planing Machine.

294. Slotting Machine.

295. Radial Drilling Machine.

296. Shaping Machine.

297. Milling Machine.

298. Gear Cutting Machine.

299. Dynamo, or Electric Motor, etc., etc.

Materials Used in Machine Construction

300. Mention the principal kinds of wood used by Mechanical Engineers, and state the purpose for which each kind of wood is most suitable.

301.* State the characteristic properties of Cast Iron and Wrought Iron. Mention several examples of machine details in which the metal used in selected on account of the possession of certain of these properties.

302.* What are the special properties possessed by Brass which make it of value in Machine Construction? Illustrate your answer by two or three examples.

303.* For large Engines the Bearings are fitted with "white metal" to lessen friction and tendency to heat. Give sketches showing how this is done; also name the composition of white metal.

304. What is Malleable Iron? Describe the process employed in the manufacture of same.

305. What do you understand by the terms (1) ductility of metals; (2) elongation; (3) tensile and torsional strain; (4) compressive strain; (5) shearing; (6) factor of safety?

306. What is Steel? How would you distinguish good Steel from bad, and what is the best way to test Steel?

307. What is meant by "hardening," and "tempering"? Describe, as an example, the process of making a Chisel for chipping Cast Iron.

308. Explain the process of "case hardening."

309. What is Bronze or Gun Metal? Why is it so well adapted for the steps of bearings, etc.?

310. Give examples of the use of Copper in Machine Construction.

311. What is meant by "stress" and "strain"?

312.* What is the tensile and crushing strength of average Cast Iron in tons per square inch? What is the safe stress per square inch for wrought Iron, and for mild Steel in Machinery, subjected to ordinary changes of load and shock?

313. What is meant by the terms "dead load" and "live load"?

314.* What is meant by the "modulus" of a machine?

315.* How much stronger is a 4″ Wrought Iron Shaft than a 2″ Wrought Iron Shaft to transmit work to machines? (ANS.—8 *times*)

316. If a shaft 7″ diameter will bear a load of 10 tons on the crank, what load will a shaft 9″ diameter sustain, the length of crank remaining the same. (ANS.—21·25 *tons*)

317. What must be the diameter in inches of a round rod of Wrought Iron, in order to sustain a load of 50 tons? It is given that a bar of Wrought Iron one square inch in section will just support a load of 25 tons. (ANS.—$1\frac{5}{8}$″)

318. Explain the process of "forging" and "welding."

318a. Why is Nickel Steel so well adapted for the armour of ships?

Miscellaneous Questions

319. What do you understand by the following terms relating to Beams: (1) Deflection. (2) Camber. (3) Bending Moment. (4) Shearing Force. (5) Resilience.

320. What will be the breaking weight at the centre of an English Oak Beam 6″ broad × 12″ deep, supposing the span to be 25′? (Constant 557.)

(ANS.—*Nearly* 19,250 *lb.*)

321. Find the breaking weight at the centre of a Cast Iron Beam 20″ deep, bottom flange 10″ × $1\frac{1}{2}$″ and 20′ span? (Constant 25.) (ANS.—$31\frac{1}{4}$ *tons*)

322. If in the last question the load was distributed along the length of Beam, what would then be the breaking weight? (ANS.—62½ *tons*)

323. Give examples of some of the straining actions to which Machines are subjected.

324. Explain the process of making a pattern for a Spur Wheel.

325. Give examples of Green Sand, Dry Sand, and Loam Moulding.

326. Sketch the ordinary forms of Moulding Boxes.

327. What do you understand by the following terms as applied to Moulding: (1) Open-sand Moulding. (2) Gates. (3) Vent Holes. (4) Stopping off. (5) Plate Moulding, etc.

328. Why is it necessary to keep a casting as uniform as possible in thickness?

329. How would you proceed to fit up a pedestal from the rough castings?

Examples for Designs

330. Design a compound Slide Rest suitable for a 9″ centre screw cutting lathe.

331. Design the overhead Countershaft suitable for driving a 12″ centre lathe.

332. Design a pair of Headstocks for a 10½″ centre double geared lathe.

333. Find the number and size of Bolts required in the cover of a Steam Engine Cylinder, 15″ diameter, working at a pressure of 120 lb. per square inch. (*The pitch not to exceed five times the diameter of bolt.*)

334. Design the fast Headstock for a 16″ centre treble geared break lathe, the outside diameter of face plate to be 5 ft.

335. Design a Connecting Rod End suitable for a horizontal Steam Engine, where the crank pin is 4″ diameter and 5½″ long.

336. Design an amateurs "treadle" lathe, with 5″ centres, and 4′ 6″ gap bed, making separate details of all the principal parts.

337. Design a Crank-Shaft Bearing, suitable for a 6″ diameter shaft. Make provision for both horizontal and vertical adjustment.

338. Design a Bench Drilling Machine, suitable for either hand or power, to drill holes up to 1″ diameter.

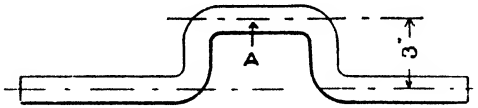
339. Design a main Steam Stop Valve, 4″ diameter. Boiler pressure 80 lb. per square inch.

340. Design an Adjustable Footstep Bearing for supporting a vertical spindle $1\frac{1}{4}$″ diameter.

Appendix to the Sixth Edition

NOTE: *In addition to this appendix, new drawings have been added on pages* 6, 7, 8, 12, 15, 16 *and* 19, *together with several new questions.*

341.*A Wrought Iron Crank Shaft is formed by bending a 2″ round bar, as shown in the sketch.



How would you proceed to turn the part marked A?

342.*With the aid of sketches, describe how the revolving table of a vertical turning mill or lathe is mounted and driven. Point out the merits of this tool for special kinds of work.

343. Sketch and describe one type of Governor suitable for (1) a steam engine; (2) for a gas or oil engine.

344. Give sketches showing the construction of a steam engine indicator, and explain how you would proceed to indicate an engine.

345. Describe the "Otto" cycle principle, on which the majority of gas engines are constructed.

Electrical Engineering

346. Sketch an electric dynamo or motor, and mark on the names of each part.

347. Give sketches showing the field magnets for a four-pole dynamo.

348.*Sketch and briefly describe the armature of a continuous current dynamo machine, without any winding, or preparation for winding, showing how the iron sheets are held fast, and how the armature is fastened to the spindle. Also show the construction of the commutator.

349. What are the advantages of driving machine tools by means of electric motors?

350. Make sketches showing the "trolley" used for conveying the electric current from the overhead wires to the tramcar.

351.* Show, by sketches, the method of holding and insulating the bars of a commutator of a continuous current dynamo. The shaft is 3″ diameter, and the outside of the bars 8″ diameter.

352.* Sketch the arrangement of the brush holder for a dynamo, showing clearly how the pressure on the commutator may be regulated, and how the lead of the brushes may be varied.

353.* Make a careful sketch of a part of the track of an electric railway in which a separate conductor is used for the return, showing clearly the way the live and return rails are respectively supported and insulated.

354. Give sketches and brief description of any type of magnetic or electric brake for tramcars, you may be acquainted with.

355. Show by neat sketches how you would support the electric motor for driving (1) a treble-geared lathe; (2) a planing machine.

Miscellaneous Questions

356. Describe how you would harden and temper (1) a lathe tool; (2) a fitters' chisel; (3) a tap; (4) a reamer; (5) a small spring.

357. Show the application of ball bearings to (1) a drill spindle; (2) a radial drilling machine arm; (3) a bicycle or motor car bearing.

358. Make a diagrammatic sketch of a suction producer gas plant, pointing out the advantages of same.

359. What are the advantages of using liquid fuel? Sketch one type of "sprayer" used for injecting the oil into a boiler furnace.

360. Show the construction of a "speed gear box" to give 8 changes of speed, suitable for driving a radial drill or other machine tool.

361. Make sketches to show the types of blades used in (1) Parson's steam turbine; (2) De Laval steam turbine, and (3) the Curtis steam turbine.

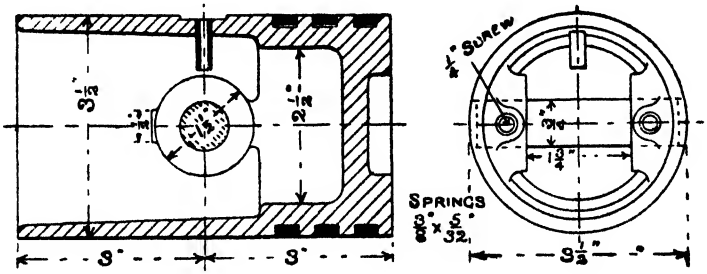
362. Sketch the driving gear for (1) a motor bicycle; (2) a motor car; (3) an electric tramcar.

363.* Give sketches showing the construction of a thrust bearing of a screw propeller shaft and how it is made adjustable.

364.* Sketch and describe the gearing appropriate to the purpose of driving a planing machine of large dimensions by an electric motor.

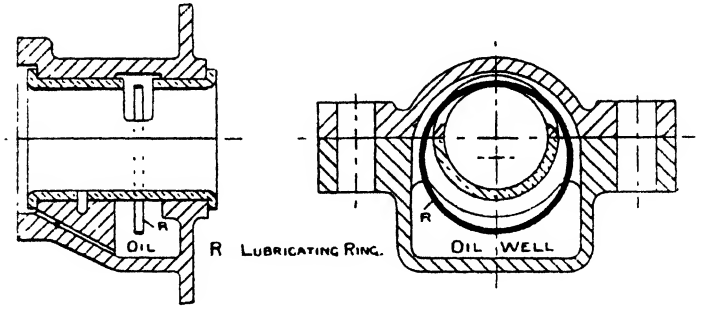
365.* Sketch the main bearing for a 9-inch shaft, arranged for forced lubrication. Show carefully the oil ways. What pressure would the oil be supplied at?

366. Sketch a Piston, suitable for an Air Compressor, and mark on the principal dimensions when the cylinder is $3\frac{1}{2}''$ diameter, and the stroke 6".



NOTE: For complete drawing of Air Compressor, see Bentley's "Sketches of Engine and Machine Details."

367. Sketch a Bearing suitable for a Motor Car, and show clearly the method of "Ring Lubrication."



MOTOR CAR BEARING

NOTE: *Answers to a large number of the Questions contained in this Book will be found in the Author's Book,* "SKETCHES OF ENGINE AND MACHINE DETAILS." (*See Advertisement.*)

Appendix to the Seventh Edition

368.* Describe the process of white-metalling the bearing for a large diameter shaft.

369.* Briefly describe, with the aid of sketches, any form of machine for finishing piston-rods by grinding.

370.* Make a sketch of a cotter joint for connecting together two bars each $1\frac{1}{2}$ inches diameter.

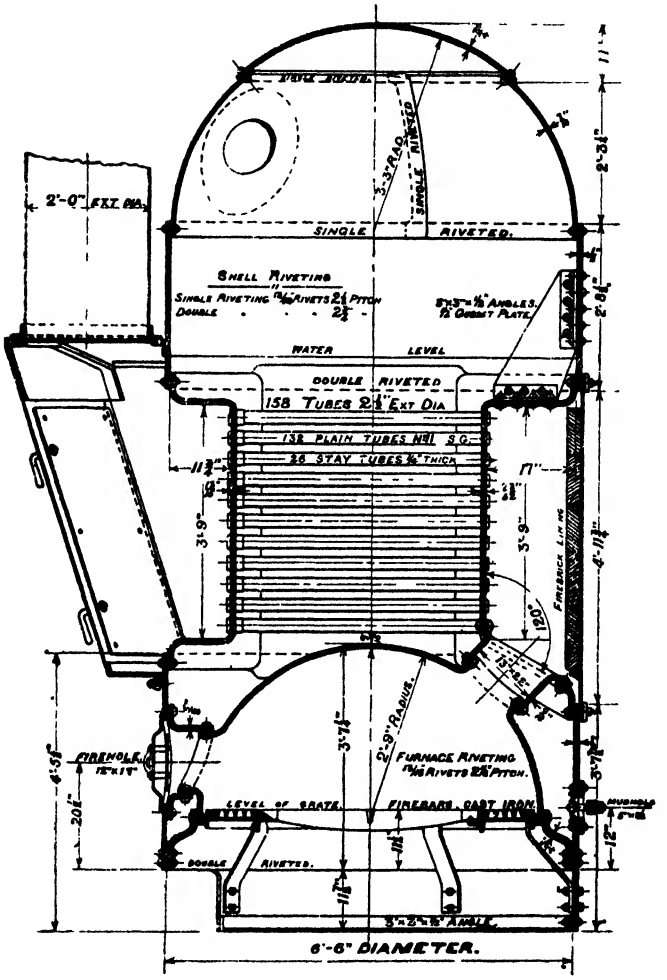
371.* Write down the values of the working stresses you would consider safe to use in connection with the design of a mild steel bar carrying a dead load; a mild steel slide-bar of an engine; and a mild steel piston-rod.

372.* Sketch either a direct loaded spring safety-valve or a Ramsbottom valve of the duplex type, and show in either case the provision made for adjusting the load on the safety-valve, and also explain the means taken to prevent the adjustment being tampered with.

373.* Make a sketch of any form of ball bearing which is suitable for supporting the main driving shaft of a machine shop. Assume that the bearings are to be fastened to rolled joists spanning the shop.

NOTE: *Drawing of a Ramsbottom duplex type of spring loaded safety valve appears at the beginning of this book.*

374. Sketch in sectional elevation a modern Vertical Boiler and insert a few of the leading dimensions.



COCHRAN'S VERTICAL MULTITUBULAR BOILER

The above boiler is designed for a working pressure of 100 *lb. per square inch. It has* 500 *square feet of heating surface and a grate area of* 22½ *square feet.*

Appendix to the Eighth Edition

Machine Tools

375. Sketch the form of either the "Vulcan," "Vickers," or "Lancashire" Drive as fitted to a planing machine.

376. Explain the advantages of accelerating devices and push button control as applied to machine tool driving.

377. Sketch the driving gear arrangement employed on a turning and boring mill.

378. Sketch a tool-box suitable for a planing or shaping machine.

379. Sketch the "lay-out" of an all-gear lathe headstock.

380. State the principle of a variable speed lathe headstock. What are its advantages?

381. Sketch and describe a four-tool turret suitable for a lathe.

382. Sketch a hexagon turret and state where these are most profitably employed.

383. Loose headstocks are frequently made with extended shoot or screwed spindle. Show how this is fed forward.

384. Show how the thrust on a loose headstock may be taken on a lathe bed.

385. Make a sketch of a "dropping-worm" as fitted to the feed shaft of a lathe.

386. Show how automatic stops may be used in combination with the above.

387. Sketch a "narrow guide" lathe bed and state its advantages.

388. Sketch a suitable arrangement of pump and piping, together with suds tray as used on a lathe or milling machine.

389. What are the relative merits of "Individual" and "Group" methods of driving machine tools by electric motors?

Workshop Questions

390. Sketch and describe one or two types of "jigs and fixtures" employed in machine shops for facilitating the rapid production of machine parts in quantities.

391. Sketch two or three types of "broaches" and explain the process of "broaching."

392. Describe a simple type of (1) thread milling machine, or (2) grinding machine.

393. Sketch a change-speed gear box suitable for driving a shaping machine and explain the advantages of same.

394. Sketch and describe the mechanism employed in a shell turning lathe for forming the "nose" of shell, and also for producing the "waved groove" for receiving the copper band.

395. Describe with sketches a modern type of belt driven forging hammer suitable for use in a Smithy or Blacksmith's shop.

396. Show the application of ball bearings to (1) a lathe spindle, (2) drilling machine spindle, and (3) line shaft hanging bearing.

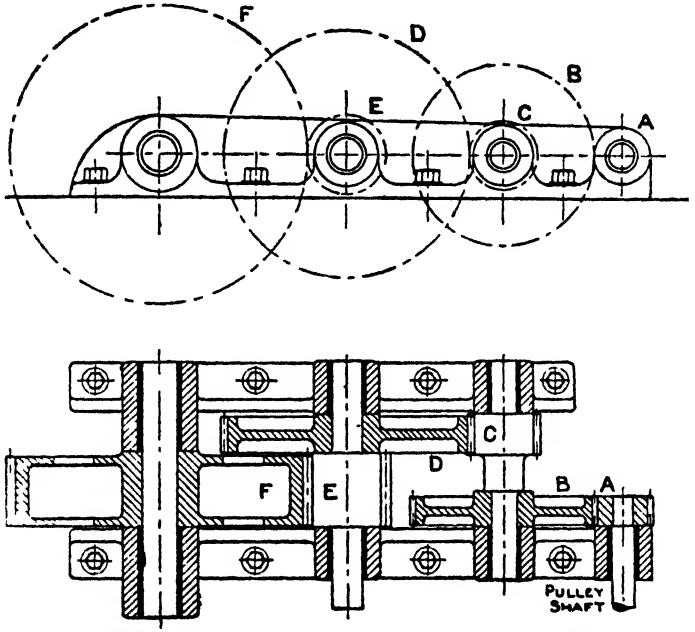
397. Describe with suitable sketches a common type of power driven Hack sawing machine suitable for cutting off bar iron stock, shafts, etc.

398. How would you proceed to cut a spur gear in a wheel-cutting machine?

399. Name two of the chief essentials for rapid production.

(ANS.—*Simplicity of design and standardisation of parts.*)

400. Sketch a suitable arrangement of gearing for driving the table of a large high speed planing machine, and show the method of calculating the cutting speed in feet per minute.



A. Pulley Shaft Pinion 22 T.4P. D. Third Shaft Wheel 75 T.3P.
B. Second Shaft Wheel 74 T.4P. E. Bull Wheel Pinion 16 T.2P.
C. Second Shaft Pinion 20 T.3P. F. Bull Wheel ... ... 60 T.2P.

The Bull Wheel meshes with the rack secured to the machine table.

The above arrangement is taken from the drawings of a 5′ 0″ square Planing Machine The gear shafts are mounted in two strong brass bushed brackets. The gears and brackets are lowered together into position in the Planing Machine Bed and securely fastened thereto.

If the Pulley Shaft makes 185 revolutions per minute on the forward stroke, the cutting speed

$$= 185 \times \frac{22}{74} \times \frac{20}{75} \times \frac{16}{60} \times 30 \times \frac{22}{7} \times \frac{1}{12} = 30{\cdot}7 \text{ feet per minute.}$$

Aircraft Machinery

401. Make a diagrammatic sketch showing the arrangement of the cylinders of one type of aeroplane engine.

402. Sketch and describe a modern type of connecting rod for aeroplane engines to be forged from special nickel-chrome steel.

403. What are the chief materials employed in the construction of an aeroplane?

404. Make skeleton drawings showing (1) the outlines of one type of British aeroplane; (2) a seaplane, and (3) a Zeppelin.

405. Show, by the aid of sketches, the construction of the "Gnome" nine cylinder engine suitable for aircraft purposes.

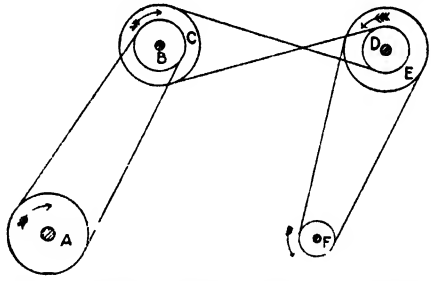
406. Sketch and describe one type of carburetter specially adapted for aeroplane engines.

407. Sketch one form of propeller suitable for aeroplane work.

Appendix to the Ninth Edition

Machine Shop Calculations
(With Answers)

408. The drawing below shows the general arrangement of the driving pulleys in a small engineering works. A lathe countershaft carrying fast and loose pulleys A which are 24″ diameter and specified to make 225 revs. per minute has just been erected and it is desired to find the correct diameter for the driving pulley B on the second line shaft. The second line shaft drive is received by pulley C 20″ diameter being driven by pulley D 12″ diameter on the first line shaft. The first drive is taken from an electric motor running at 1000 revs. per minute. The motor pulley F is 10″ diameter and drives a 20″ diameter pulley E on the first line shaft. In addition, work out the speeds of the first and second line shafts.



(*The arrows indicate direction of rotation.*)

Diameter of pulley B

$$= \frac{20 \times 20 \times 24 \times 225}{1000 \times 10 \times 12} = 18'' \text{ diameter.}$$

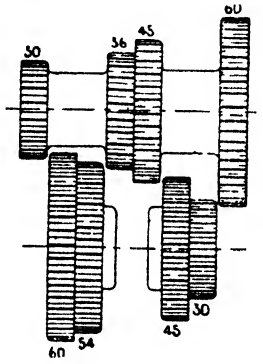
Speed of first line shaft

$$= \frac{1000 \times 10}{20} = 500 \text{ revs. per minute.}$$

Speed of second line shaft

$$= \frac{500 \times 12}{20} = 300 \text{ revs. per minute.}$$

409. Sketch the arrangement of the gearing in a simple type of "all geared head" suitable for driving a small lathe. State other methods of obtaining the speed changes in addition to the "sliding gear" arrangement shown in the diagram. If the top gear shaft is run at 250 revs. per minute, what would be the four spindle speeds if the numbers of teeth in the gear wheels are as shown in diagram?



In addition to the "sliding gear" type of head, both positive claw clutches and friction clutches are frequently employed. In some of the larger heads it is not unusual to find a combination of all the three methods.

Spindle speeds

$$\frac{250 \times 30}{60} = 125 \qquad \frac{250 \times 45}{45} = 250$$

$$\frac{250 \times 36}{54} = 166 \qquad \frac{250 \times 60}{30} = 500 \text{ revs. per minute.}$$

410. In a rack driven planing machine, the cutting speed is 30′ per minute and the return speed 90′ per minute, the machine pulleys making 210 and 630 revolutions per minute on the respective strokes. If the countershaft is run at 280 revolutions per minute, and the machine pulleys are 16″ diameter for the cutting stroke and 12″ for the return stroke, calculate the diameters of the two driving pulleys on the countershaft.

Cutting stroke, countershaft pulley diameter

$$= \frac{210 \times 16}{280} = 12'' \text{ diameter.}$$

Return stroke, countershaft pulley diameter

$$= \frac{630 \times 12}{280} = 27'' \text{ diameter.}$$

411. In a screw driven planing machine, the table is traversed backward and forward by means of a double thread screw, 3″ lead, $1\frac{1}{2}$″ pitch. Calculate the revolutions per minute of the machine pulleys if the cutting speed is 30′ per minute and the return speed 60′ per minute. If the machine pulleys are 18″ diameter and the countershaft runs at 180 revolutions per minute, what will be the diameters of the two countershaft pulleys?

Revolutions per minute of machine pulleys on cutting stroke

$$= \frac{30 \times 12}{3} = 120$$

Revolutions per minute of machine pulleys on return stroke

$$= \frac{60 \times 12}{3} = 240$$

Countershaft, cutting stroke pulley diameter $= \frac{120 \times 18}{180} = 12''$

Countershaft, return stroke pulley diameter $= \frac{240 \times 18}{180} = 24''$

412. In medium and large size planing machines, boring and turning mills, and plano-milling machines it is usual for the cross-slide carrying the tool boxes to be raised and lowered on the machine standards either by hand or power. A cross-shaft on the top of the machine, may transmit motion to the vertical elevating screws in the standards, either by means of bevel gearing or worm gearing. The drive to the cross-shaft is generally by open and crossed belts so that movement may be made in either direction. Calculate the raising and lowering

speed, if the cross-shaft makes 192 revolutions per minute and operates bevel gears having 15 and 30 teeth respectively, while the elevating screws are $\frac{1}{2}''$ lead, $\frac{1}{4}''$ pitch.

Raising and lowering speed of cross-slide

$$= 192 \times \frac{15}{30} \times \tfrac{1}{2}'' = 48'' \text{ per minute.}$$

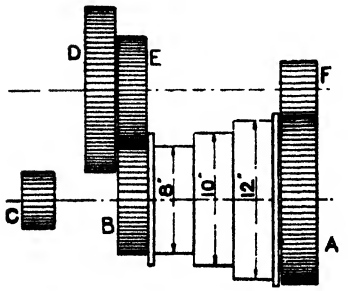
413. Where the elevating motion for a planing machine cross-slide is obtained by worm gear, calculate the speed necessary for the cross-shaft if a raising and lowering speed of 6′ per minute is required. Double thread worms and worm wheels having 16 teeth being mounted at the top of the elevating screws which are $1\frac{1}{2}''$ lead, $\frac{1}{2}''$ pitch.

Revolutions per minute of cross-shaft

$$= (6 \times 12) \div (2/16 \times 1\tfrac{1}{2})$$

$$= \frac{72}{\frac{3}{16}} = \frac{72 \times 16}{3} = 384.$$

414. The accompanying drawing shows the driving arrangement for a small boring and turning mill. Three speeds are obtained with the gearing out of mesh, three speeds when B engages with E and F with A, and other three speeds when C engages with D and F with A, totalling nine speeds. The drive is taken from the cone shaft by a pair of mitre gears having 25 teeth each and thence to the table of the machine by a spur pinion having 24 teeth and a spur wheel of 72 teeth. If the countershaft carries a similar three-speed cone to that shown, but in reversed order, calculate the nine speeds of the machine table. The countershaft speed is 270 revs. per minute.



A...Spindle Wheel, 66 teeth.
B...Large Cone Pinion, 52 teeth.
C...Small Cone Pinion, 26 teeth.
D...Large Barrel Wheel, 78 teeth.
E...Small Barrel Wheel, 52 teeth.
F...Barrel Pinion, 22 teeth.

Ratio of gearing on the driving headstock

$$\text{(1) Small Gear ratio} = \frac{B}{E} \times \frac{F}{A} = \frac{52}{52} \times \frac{22}{66} = \frac{1}{3} \text{ or 3 to 1.}$$

$$\text{(2) Large Gear ratio} = \frac{C}{D} \times \frac{F}{A} = \frac{26}{78} \times \frac{22}{66} = \frac{1}{9} \text{ or 9 to 1.}$$

Ratio of mitre and spur gearing on the machine

$$= \frac{25}{25} \times \frac{24}{72} = \frac{1}{3} \text{ or 3 to 1.}$$

Revolutions of table with headstock gearing out of mesh

$$(1)\ \frac{270 \times 12}{8} \times \frac{1}{3} = 135 \qquad (2)\ \frac{270 \times 10}{10} \times \frac{1}{3} = 90 \qquad (3)\ \frac{270 \times 8}{12} \times \frac{1}{3} = 60$$

Revolutions of table with headstock small gear ratio in mesh

$$(4)\ \frac{135}{3} = 45. \qquad (5)\ \frac{90}{3} = 30. \qquad (6)\ \frac{60}{3} = 20.$$

Revolutions of table with headstock large gear ratio in mesh

$$(7)\ \frac{135}{9} = 15. \qquad (8)\ \frac{90}{9} = 10. \qquad (9)\ \frac{60}{9} = 6{\cdot}6.$$

415. The rotation of the spindle in a radial drilling machine is obtained from a horizontal shaft by means of two spur gears having 32 teeth each and thence by a pair of mitre gears. The vertical traverse or feed motion of the spindle is taken from the second spur gear shaft by means of a three-speed cone, 6″, 7½″ and 9″ diameter. which drives a similar cone placed reverse hand on a lower horizontal worm shaft. The worm on this shaft is single threaded and meshes with a worm wheel having 24 teeth. This wheel is mounted at the bottom end of a vertical shaft, while at the top end is another single thread worm, which meshes with a 30 tooth worm wheel. This latter worm wheel is combined with a pinion having 16 teeth, ½″ pitch, which operates the rack sleeve on